

TRAUMATIC SEPARATION OF THE EPIPHYSES OF THE LOWER EXTREMITY.

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THE subject of separation of the epiphyses is one of considerable interest and no little importance when we consider the comparative frequency and possible results, especially shortening of the limb with resulting lameness in the lower extremity.

In the Guy's Hospital Reports of 1889 I have dealt with separations in the upper extremity, and now present a collection of similar cases in the lower limb.

SEPARATIONS AT THE UPPER END OF THE FEMUR.

The upper epiphysis of the femur is developed from three distinct centres: for the head, the greater trochanter and the lesser trochanter. These are united in the reverse order of the appearance of their ossific nuclei, so that the lesser trochanter is united to the shaft about the seventeenth year, the greater trochanter about the eighteenth, and the head from the eighteenth to the nineteenth year. The neck of the femur is formed by an extension of ossification from the shaft.

Under our notice separations of the head and greater trochanter will pass, but of separation of the epiphysis of the lesser trochanter I am unable to find any case; indeed, except by muscular action, I think it very unlikely to occur on account of its very deep and well-protected situation and its short life-history as a bony nucleus, merely extending from the thirteenth to the seventeenth year.

CASE I.—A. W. MAYO ROBSON.¹ W. C., aged five years, was seen on account of lameness in the left lower extremity. Four years previously she was thrown up in the air by her uncle, who failed to catch her, letting her fall heavily on the left side. No treatment but rest. Symptoms: Marked limp on walking, leaning to the left; well-marked eversion of the foot, which could, however, be brought parallel to the right without giving pain; ability to completely flex and extend the thigh; left limb three-fourths of an inch shortening, and greater trochanter was raised three-fourths of an inch above Nélaton's line; and Bryant's line was three-fourths of an inch shorter on the injured side; the folds of the buttocks were well marked; on flexing and rotating inward of the left femur the fingers could clearly feel the neck as far as the head, but the caput femoris was apparently in the acetabulum, and *not* attached to the cervix.

Remarks.—"The case related is either a fracture through the neck of the femur or a separation of its upper epiphysis. I believe it to be the latter, and in this opinion I am supported by my colleagues."

CASE II.²—Boy, aged ten, fell out of first-floor window; foot everted and scarcely any shortening; movements of thigh free and nearly painless; flexion of the knee and rotation outward gave a very distinct sensation of dummy crepitus within the hip-joint as if one articular surface had slipped off another; and this led me to suppose that separation of the epiphysis of the caput femoris had occurred with the capsule. This opinion was confirmed by Green.

Treatment.—Double inclined plane; result good.

CASE III.—*Supposed Separation.*—F. N. HAMILTON.³ A. W., aged fifteen, fell from the fourth story of a house; next day I found the right thigh shortened three-fourths of an inch and slightly abducted; toes everted; under chloroform, dull crepitus in the joint, unlike that of broken bone.

Treatment.—Extension; fifteen pounds kept it in position, but two weeks afterwards the limb was found to be shortened half an inch, so four more pounds were then added. "I believe it to have been a separation of the upper epiphysis."

CASE IV.—*Supposed Separation.*—PACKARD.⁴ A young adult,

¹ Lancet, Vol. II, 1886, p. 343.

² South's Chelius, Vol. I, p. 565.

³ Fractures and Dislocations, p. 374.

⁴ Inter. Encyc. of Surgery, Vol. IV, p. 198.

aged nineteen, fell from a high wagon-seat and sustained what appeared to be a fracture of the neck of the femur. He was treated by weight extension and a plaster-of-Paris spica, and in six weeks was walking about.

Remarks.—"I believe the lesion was really a separation of the epiphysis."

CASE V.—*Post's Case.*—HAMILTON.¹ A girl, sixteen years old, made a false step with a child in her arms, and, feeling something give way, was obliged to lean against a wall. Next day the affected limb was found to be one inch short, movable, toes turned outward, no swelling, some slight pain at the upper part of the thigh; the trochanter major moved with the shaft; there was also crepitus. "From the age of the patient and the slight amount of violence, Post thought a separation of the epiphysis had occurred."

Treatment.—Extension. Result, half an inch shortening.

CASE VI.—JONATHAN HUTCHINSON.² Mr. Hutchinson was sent for, one night, to the London Hospital to see a patient with supposed dislocation of the hip. The house-surgeon believed he had reduced it more than once, but it had slipped again.

Boy, aged eighteen, was knocked violently backward by an explosion of gunpowder. Symptoms: Left limb slightly everted and shortened one inch; the great trochanter moved with the shaft; the limb could be drawn down, but it slipped up again as soon as traction was remitted. No true bony crepitus was elicited, but a rough grating sensation could be felt.

Treatment.—Long outside splint and perineal band. Result: Perfect, with good bony union. In Mr. Hutchinson's opinion the diagnosis lay between extra-capsular fracture and separation of epiphysis.

CASE VII.—*Autopsy.*³—Patient, fifteen years old, was run over by a wagon. Symptoms: Shortening, eversion, and inability to move the limb. The patient died in a few hours.

Post-mortem.—The separation was complete along the epiphyseal line, and the head was attached to the neck by a strip of periosteum only two inches wide; the capsule was torn at its inner portion.

CASE VIII.—BARTON.⁴ John L., aged fifteen, fell lightly to the

¹ Fractures and Dislocations, p. 374.

² Med. Times and Gaz., 1866, Vol. 1, p. 195.

³ Les Bulletins de la Société Anatomique, 1867, p. 283.

⁴ Med. News, 1886, Vol. 11, p. 43.

ground supporting his weight by his hands. The hip can scarcely have touched the ground. Symptoms: Shortening one inch; eversion of foot, trochanter above Nélaton's line. Under ether, the limb rotated as readily as its fellow, but the trochanter described a circle of less radius than normal. On extension, crepitus of an unusual kind was felt.

Remarks.—After excluding dislocation, Barton diagnosed separation of the epiphysis. Results: One year later shortening one and a half inches, but good movement of the limb.

CASE IX.—MAUNDER.¹ Boy, aged fourteen, received a blow on the front of his thigh and fell upon his hip. He walked home, some hundred yards, leaning on the shoulder of a comrade. Symptoms: limb rotated outward, shortened one-half to three-quarters of an inch; much pain. Examination under chloroform, the limb could be drawn down to its normal length and a soft crepitus was felt about the head of the bone. Mr. Hutchinson was invited to see the case, and both he and Mr. Maunder concluded that it was one of separation of the epiphysis.

Specimens.—The London Hospital Museum contains “the pelvis of a rabbit with both femora, showing separation of the epiphysis of the head of both femora. The contiguous surface of the epiphysis and shaft have been partly smoothed by friction. The specimen was from a doe-rabbit, which had never thriven well. The separation of the epiphysis was attributed to the amorous violence of a buck-rabbit.”²

Remarks.—From the fatal case No. 7, it will be gathered that the disjunction occurs within the capsule, and, therefore, its symptoms closely resemble those of a non-impacted intra-capsular fracture of the neck.

It is a rare injury. Holmes says: ³ “Its disjunction is unknown except in the fœtus, and in children we find dislocation of the hip occurring rather than separation of the epiphysis.” Hamilton states that he has either met with or found reported four cases. The total number of cases, veritable and reputed, I have been able to collect is fourteen, from all sources. Of these I have selected nine as being more or less to the point.

¹ *Lancet*, 1870, Vol. 1, p. 192.

² *London Hosp. Mus. Catalogue*.

³ *Surgical Diseases of Childhood*, p. 258.

Let me briefly analyze these nine instances. Of these, only one, No. VII, was verified by autopsy. In the other cases there was strong clinical evidence of the existence of the lesion in question. Thus, Case I was regarded by Robson either as an intra-capsular fracture of the neck of the femur or a diastasis. He inclined to the latter, and his opinion received the support of his colleagues. South's case, No. II, is admitted by subsequent writers and authorities to have been a genuine case. Hamilton's, Case III, is probably veracious, the dull crepitus being the central fact. Post's, Case V, was either an intra-capsular fracture or diastasis; but, considering the rarity of the former occurrence in young life, in all these doubtful cases where the diagnosis lies between the two conditions, the presumption is in favor of separation, if the patient is under nineteen. Barton's, Case VIII: here the diagnosis lay between rupture of the Y-ligament, absorption of the head of the femur from coxitis or diastasis; but he finally decided, and rightly, I think, in favor of the latter. Mr. Maunder's, Case IX, appears to be genuine, as both he and Mr. Hutchinson concurred in the diagnosis when the patient was examined under chloroform. It is much to be regretted that in Case VII, the only one in which an autopsy occurred, no other symptoms are recorded except shortening, eversion, and inability to move the limb: an opportunity such as this of clearing up doubtful points rarely presents itself.

It is very noticeable that, whereas intra-capsular fracture usually results from slight violence, separation follows great violence; thus, falls from the fourth story, from a first-floor window, from a high wagon-seat, and a knock-down blow in an explosion of gunpowder are quoted as causes. In one other instance a boy had been run over by a wagon.

It is worthy of remark that the average age of nine sufferers was somewhat over fourteen; that is, the separation occurs when the head of the femur no longer consists mainly of cartilage, but is nearly all bone, and therefore incapable to a large extent of accommodating itself to sudden shocks. The thin epiphyseal line is the weakest part of the neck, and therefore indirect violence spends itself chiefly at that point.

Before entering on the symptoms and diagnosis, I wish to allude to an anatomical point. Amesbury¹ says that the synovial membrane immediately investing the neck of the femur is often raised into longitudinal folds by strong ligamentous bands. Once Packard found a vessel of some size running along one of these folds. Fragments may be kept together by these bands.

Symptoms.—*Pain* may be severe or slight.

Crepitus of a peculiar dummy variety, or cartilaginous, or rough grating is felt.

Shortening in Case II equal to one-eighth of an inch, in Case III, three-fourths of an inch, in Case V, one inch, in Case VI, one inch, in Case IX, three-fourths of an inch; average, three-fourths of an inch.

Eversion occurred slightly in two cases, and more marked in two others.

Active Movements.—Their presence or absence will depend upon whether the ligamentous bands already spoken of are left intact. They may actually be so at the time of injury; but the patient finding that, though severely hurt, he is yet able to walk, in his attempt breaks them down. This occurred, perhaps, in Cases V and IX.

Passive Movements.—These are generally free.

Recurrence of Deformity occurs when extension is remitted. Other symptoms are the elevation of the trochanter above Nélaton's line, and the swelling and ecchymosis.

Diagnosis.—From intra-capsular fracture separation of the epiphysis is really a solution of continuity *within* the capsule, but, unlike fracture, is incapable of impaction. It seems to me that excepting in two points the diagnosis is in the highest degree obscure. The points are (a) the age at which fracture occurs. Hyde's tables² present but two cases of intra-capsular fracture under fifty. (b) Bearing in mind that there is under the twentieth year a weak spot in the neck at the epiphyseal line, it is more reasonable to expect that this has given way, rather than the stronger tissue on either side.

¹ Todd's Encyclopædia of Anatomy.

² Medical Record, 1873.

From extra-capsular fracture, both here and in diastasis, bruising is great, and the soft parts injured; they occur in young life; there is shortening and eversion. But in no instance of separation of epiphysis is there any mention of fissuring of the trochanter major,—a common occurrence in extra-capsular fracture. If no impaction occur, true bony crepitus is felt, and this is widely different from the “dummy” crepitus of diastasis. In fracture shortening is greater, two inches or more, while in separation it is three-fourths of an inch on the average. In Hyde's tables of extra-capsular fracture ten were under fifty, and seven at or over fifty; the three youngest were respectively thirty, twenty-five, and twenty; all above the average age of diastasis, fifteen.

From fracture of the rim of the acetabulum: In both crepitus will be present; in both the deformity reappears after reduction. But in fracture of the acetabulum, owing to the upper and posterior part of the cup being broken, a dorsal dislocation of the head of the femur occurs, and the head can be felt in an abnormal position. This is not the case in separation of the epiphysis. From dislocation of the hip: Unless great bruising and swelling occur, the fixity of the limb, and the permanency of the reduction in dislocation, should be sufficient to clear up the diagnosis.

Mr. Hutchinson,¹ in a clinical lecture on the diagnosis of injuries about the hip-joint, laid down certain general rules for guidance in obscure cases. These were briefly: “(1) Always use chloroform or ether in difficult cases. (2) Do not be misled by the patient's statement, as to what he can accomplish with the injured limb, into the belief that he has sustained no serious injury; for instance, patients with dislocation are often able to lift the limb from the bed, and sometimes to walk. This occurs, too, in impacted extra-capsular fracture, in intra-capsular fracture, when the tissues covering the neck of the femur are not torn through, and probably in cases of separation. (3) In dislocation range of movement is decreased, in fracture it is increased. There may, however, be diminished movement in fracture due either to rigidity or to impaction. (4) Take into consideration the age of the patient and the nature of the injury. (5) Ever-

¹ Medical Times and Gazette, 1866, Vol. I, p. 194.

sion is the rule in fracture and separation of the epiphysis; but inversion sometimes occurs in fracture, and then there is some resemblance to dorsal dislocation."

Complications.—In Case VII, which was fatal, it is noted that the periosteum was stripped up on the lower and inner part of the neck, and the capsule was torn at its inner portion. There is no record of the separation being compound (*a priori*, a very unlikely occurrence), or of the injury being complicated by wound of vessels or nerves.

Effects.—(a) As to bony union, Hamilton writes, "bony union after epiphyseal fracture of the neck of the femur is a supposition which, as far as I can learn, no surgeon has yet ventured to make." Hutchinson, however, notes that in Case VI, "the union was quite firm." It occurs to one, however, that a fallacy may creep in. If there be sufficient inflammation to ankylose the head of the femur firmly, strong fibrous union will result in a false joint. (b) As to growth and length of the limb, shortening varied from six weeks to four years afterwards to the extent of one-fourth to one and a half inches. (c) As to movement,—generally good. (d) It is remarkable that while we are compelled to notice in diastasis elsewhere inflammation, followed by suppuration and necrosis, either of the shaft or the epiphysis (separation of the great trochanter), we find no record of suppuration or necrosis following separation, or what is believed to be such, of the epiphysis of the caput femoris. One would, knowing how often in coxitis the head of the femur is found separated and forming a marble-like sequestrum, have expected this result to have followed above all others in traumatic lesions. Since we have a large mass of bone, but feebly supplied with blood-vessels, suddenly deprived of the main bulk of its nutrition; and yet apparently it does not die. What explanation can be given? I venture to think that under the nomenclature of acute coxitis, acute suppuration, and disorganization of the hip, some cases of separated epiphysis have crept in; and the sequestrum has been looked upon rather as the result of joint inflammation than as the cause.

Treatment.—In South's case it was put up on a double

inclined plane. Most of the other cases were treated by extension either by weight and pulley or by the long outside splint and perineal band. Mr. Bryant's double splint is doubtless an excellent apparatus for fractures and similar lesions in the neighborhood of the hip in children, securing as it does due extension and immobility, at the same time rendering it easy to move the patient without displacing the fragments. Shortening here is not so important as at first appears, since growth of the femur in length is mainly dependent upon the integrity of the lower epiphysis. In the young, however, we must be on the watch for signs of lateral curvature of the spine secondary to any obliquity of the pelvis. In a child extension should be kept up for at least four weeks; but in patients beyond puberty from five to six weeks. Cautious movements should be made at first in allowing flexion at the hip; and if unproductive of pain or irritation, more and more freedom may be accorded to the patient, until he can move the limb without hindrance, after which with equal caution he may be encouraged to put the foot to the ground and bear his weight upon it.

SEPARATION OF THE EPIPHYSIS OF THE GREAT TROCHANTER.

CASE I.—ASTON KEY. A young girl, aged sixteen, in crossing the street tripped, and in falling struck the trochanter against the curbstone. She immediately rose and, without much pain or difficulty, walked home; but feeling an increase of pain was admitted five days afterwards into Guy's. The right leg was considerably *everted* and appeared to be one-half inch longer than the sound one. It admitted of passive movement in all directions, but abduction gave her considerable pain. She had perfect command over all the muscles except the internal rotators. No crepitus or displacement of bone could be detected on the closest examination.

Nine days afterwards she died. Post-mortem examination revealed a fracture which had detached the trochanter, but without tearing through the tendons attached to the outer side of the process. This so effectually prevented all motion of the fractured part that the injury could not have been detected during the life of the patient.¹

¹ Museum specimen, Guy's Hospital, No. 1106.

CASE II.¹—In Agnew's collection is a well-marked example accompanied by a fracture of the condyles of the femur.

CASE III.—J. MCCARTHY.² A girl, aged eight, was brought to the London Hospital with a large swelling over the sacrum. The house-surgeon on duty considered the child too ill for examination, and death ensued within a few hours after admission.

Post-mortem Examination.—The left foot was everted; there was an abscess in the right sterno-clavicular articulation, pyæmic pericarditis, pleurisy and pneumonia, also a large collection of pus in the pelvis, which was connected along the tendon of the pyriformis with another abscess round the neck of the femur.

The trochanteric epiphysis was completely detached from the shaft, but was held in position by tendinous attachments and reflexions of the capsule. The history of the case was that the child, while playing about the room, had fallen on her left side about a week before being brought to the hospital; that nothing more had been noticed till on the Saturday night following, the older sister, while washing the child, observed a lump over the left hip; that the child was kept in bed in consequence; but two or three days later seemed to have some difficulty in breathing, and so was sent to the hospital; that even then the child walked holding by her mother's hand for about half a mile and did not complain of any pain; and that until she fell she had never had any illness.

Points of elucidation required in the case: (1) Did the abscess around the neck of the femur and within the pelvis extend to the site of detachment of the epiphysis? (2) Were the separated epiphyseal surfaces normal, and was the cartilage inflamed or was it lost?³

CASE IV.—MR. POLAND.⁴ Occurred in a boy, aged twelve, from a direct blow, and was characterized by a projection and thickening of the great trochanter.

CASE V.—I. H. ASHTON. A boy, sixteen years old, was swung round by his friend, being held by the arm and leg, and then allowed to fall to the ground. He was able to work for some days, then followed pain and stiffness in the hip-joint and, finally, swelling of the whole femur, but no crepitation could be felt. An abscess formed over the trochanter with high fever and was opened. The patient

¹ Agnew's Surgery, Vol. I, p. 945.

² Path. Soc. Trans., Vol. xxv, p. 200.

³ London Hosp. Mus., No. 424.

⁴ Bryant's Surgery, 4th Ed., Vol. II, p. 447.

died fourteen days afterwards. At the post-mortem examination, the trochanter was found entirely separated from the shaft, and the hip-joint disorganized. The neck of the femur was necrosed.

Remarks.—This injury is by no means uncommon as a complication of extra-capsular fracture, but the separation of the epiphysis *alone* is a rare accident. Three cases were verified by autopsy. Of specimens extant there are: Agnew's, in his own collection; Warren's, a doubtful one from the dissecting room, Trinity College, Dublin, and he states that there are three others in the same Museum; Aston Key's, in the Guy's Museum; and McCarthy's, in the London Hospital Museum, while the whereabouts of Ashton's specimen is not stated.

As to the cause, it seems to have been due in all the cases above mentioned to direct violence, and this fact coincides with Packard's¹ opinion, who says that the cause would seem to be always direct violence.

Symptoms.—As far as the verified cases assist us, they are as follows:

(1) History of injury in some cases slight, in others severe. But I see no reason to doubt that muscular action may be a cause, considering the number, size, and power of the muscles attached to this epiphysis.

(2) Age, under seventeen.

(3) Pain, aggravated on pressure of the part, and slight swelling.

(4) If the trochanter is broken away completely from the shaft it is drawn upward, inward, and backward, by the action of the attached muscular fibres, and in such a case will be transferred from its normal place to that occupied by the head of the femur in dorsal dislocation. There may or may not be eversion of the foot. But judging from the above cases, it will as often happen that, although the epiphyseal line exhibits a distinct fissure, the trochanter is not drawn away from the shaft, owing to extensions of the capsule of the hip-joint, and to the numerous tendons attached to and passing over the trochanter.

¹ Internat. Encyc. Surg., Vol. IV, p. 199.

(5) If the fragments be widely separated crepitus can only be obtained on drawing the upper one down. If, however, they be close together a "dummy" crepitus may be felt.

(6) Movements after injury. Sometimes the limb is not immediately disabled, but the patient is able to walk about even to the extent of half a mile. Should, however, the fragments be widely separated there will be total disablement of the limb.

Diagnosis.—(1) From extra-capsular fracture of the neck of the femur. It should be remembered that separation or fissure of the great trochanter often co-exists with this; but if not, the following signs of fractured neck are missing in separation of the epiphysis: (a) there is no shortening of the limb; (b) in rotating the limb the trochanter does not describe a smaller arc than normal, but will either fail to follow the movements of the thigh, or, if the fibrous covering be untorn, will describe a normal arc.

(2) From dislocation of the hip on to the dorsum ilii, this doubt can only arise when the separated fragment is pulled upward and backward. Stanley, speaking of the danger of comparison between these two lesions, "urges the positive resemblance of the fractured portion of the trochanter to the head of the femur, the former occupying the same place as the latter on dislocation. And if with these circumstances there should happen to be an inversion of the injured limb the difficulty of the diagnosis is much increased." But I think a brief examination under chloroform would readily clear up all doubts.

(3) From simple contusion or bruise. In this case it is better to err on the safe side, and remembering what severe results occur from contusions of this part, to urge the patient to remain in bed at least for a few days, until the surgeon has satisfied himself that there is no gross injury to the bone. The results in Cases I and III might not probably have been so severe had the patients rested for some days after the injury. By that time, owing to disappearance of the swelling, any undue mobility about the trochanter could have been felt.

Results.—In Cases III and V large abscesses followed with

pyæmia and death. In the first case the trochanter was bare, separated from the shaft, but still retaining some of its tendinous attachments. In the second case it is stated that the trochanter was found entirely separated from the shaft, and the hip-joint disorganized. We may ask, Why do such fatal results occur in several of the recorded cases of disjunction of this epiphysis, whereas diastasis of the lower end of the humerus and femur (apparently a much greater injury) yields so small a percentage of sequent pyæmia? I think the explanation may be found in two facts. In the first place, the separated portion is a distinct process, and derives its main nutriment from the shaft. In the second place, the tendons attached and the prolongations of the capsule invest it with a continuous more or less avascular membrane, which does not take upon itself the usual *rôle* of blood supply, which falls to the periosteum. Under these circumstances, then, with the irritation of walking following on severe injury, a piece of bone so feebly nourished as the trochanter rapidly necroses with sharp formation of pus.

Treatment.—If the trochanteric epiphysis be entirely separated an attempt should be made to replace it and fix it. Sir Astley Cooper's¹ belt and pad might be used with great advantage, or the object might be well accompanied by means of a compress and strapping. Malgaigne suggested abducting and everting the limb, so as to lessen the distance between the shaft and the fragment. Packard surmises that some contrivance similar to Malgaigne's hooks would be useful. But personally I should be very loath to employ any such contrivance, bearing in mind the possibility of suppuration and pyæmia. It is possible, however, that Thomas's hip-splint would serve all the purposes of treatment.

SEPARATION OF THE LOWER EPIPHYSIS OF THE FEMUR.

CASE I.—MAUNDER.² A lad, aged twenty, slipped on to his back with a knee bent under him. On examination the limb had the position of genu-valgum; he could flex the thigh slightly on the

¹ Fractures and Dislocations, p. 180.

² Lancet, 1870, Vol. 1, p. 192.

pelvis; and then the knee-joint appeared higher up the thigh than usual; the condyles of the femur, head of tibia, and patella had their normal relations, and the loss of continuity corresponded to the junction of the condyles with the shaft of the femur; a *soft* crepitus was readily elicited.

CASE II.—CLEMENT DUKE.¹ Mr. X., aged eighteen, whilst playing, was pushed on the outer side of the right leg, the limbs being extended and abducted. He suddenly felt acute pain, and fell down with the leg powerless. On examination knee-joint not swollen, no distortion perceptible to the eye, foot not twisted nor everted, limb slightly shortened on measurement; on partial flexion of the leg a movement was felt like two smooth surfaces rubbing over one another; the situation of this rub corresponded to a slight depression two inches above the knee; posteriorly the upper end of the lower fragment could be felt in the popliteal space; the diagnosis of separation of the epiphysis was made.

Treatment.—Long outside splint with perineal band and small, straight, back splint, with a pad sewn on it to keep the lower fragment from slipping out of place. Result: firm union at the end of six weeks; no shortening and no thickening at the site of fracture.

CASE III.—HILTON.² John H., aged eighteen, while carrying a hod of bricks down the slope of a railway embankment, slipped and fell with his legs doubled under him. During the fall he felt a most severe pain in the left knee, and was quite unable to straighten the limb. On examination the left thigh and knee were found to be greatly swollen, the knee was semi-flexed and the foot slightly everted; one and a half inches above the upper border of the patella the lower end of the shaft of the femur could be distinguished; its anterior edge projected forward and was well defined; in the popliteal space a considerable projection was easily felt beyond the lower end of the shaft of the bone. Attempts were made both without and with chloroform on that day to reduce the deformity, but on the following day, Mr. Hilton, with the aid of chloroform, having extended the limb to the utmost, with considerable force pushed backward the shaft of the bone, and then secured the parts in that position by means of a back splint and strapping. A week afterwards, while lifting the lad to another bed, the apparatus got sufficiently disturbed to permit of a recurrence of the displace-

¹ Brit. Med. Journ., 1874, Vol. II, p. 402.

² Med. Times and Gaz., February 12, 1859.

ment, but the normal position was secured under chloroform with still greater difficulty than at first. Seven weeks from the date of accident the apparatus was removed, the bones being found firmly united; no thickening at the site of injury was perceptible, and the motions of the knee were perfect. In this case no crepitus was ever felt; but there could be little doubt as to the accuracy of the diagnosis.

CASE IV.—*Separation of Epiphysis with Torn Popliteal Artery and Vein; Amputation.*—MR. HUTCHINSON.¹ A child, aged eighteen months, was run over in the street. Amputation was resorted to on account of the torn artery and vein. On dissection it was found that the lower epiphysis of the femur was completely detached and carried forward; there was extensive laceration and detachment of periosteum; the exposed surface of the epiphysis was covered with cartilage, but none was found on the shaft; some small spiculæ of bone had been broken off and carried with the epiphysis.

CASE V.—TAPRET and CHEUET.² A child of nine and a half years was sitting on the tail-board of a cart, when his leg caught in the wheel. A large transverse wound was caused at the posterior aspect of the knee, and much hæmorrhage ensued. He was found to have separation of the lower epiphysis of the femur. Amputation was performed.

CASE VI.—*Separation of the Lower Epiphysis of the Femur; Gangrene; Amputation; Recovery.*—WHEELHOUSE.³ A boy, aged seventeen, was caught in some machinery and his leg was violently twisted round. A lesion low down in the shaft of the femur was diagnosed, but the displacement could not be rectified; gangrene set in after a few days, and amputation was performed. On examination the lower epiphysis of the femur had been torn from its connection with the shaft, but had remained almost *in situ*; the shaft had been driven into the popliteal space, and had so stretched the popliteal vein that gangrene was inevitable.

CASE VII.—A. F. MACGILL.⁴ The patient, a boy, aged fifteen, while sitting at his work with his feet on the ground, centre-punching a boiler-plate, was struck on the lower end of the femur above the left knee by the heavy iron plate, which suddenly slipped. He was im-

¹ Trans. Path. Soc., Vol. XIII, p. 183.

² Bull. de la Soc. Anat. de Paris, June 10, 1875, p. 25.

³ Brit. Med. Jour., 1885, Vol. 1, p. 60.

⁴ Med. Times, 1884, Vol. 1, p. 695.

mediately disabled and unable to walk. On examination the left leg was slightly flexed and everted, with general swelling about the knee-joint. The anterior surface of the patella lay in a plane one and a half inches in front of the shaft of the femur; behind the patella could be felt a mass of bone corresponding in shape to the lower epiphysis of the femur, which, therefore, lay in front of the lower end of the shaft, the articular surface looking downward and forward; posteriorly the broken lower end of the shaft of the femur could be felt; the popliteal vessels were displaced backward, and could be felt beating under the skin; the measurement of the injured limb opposite the upper border of the patella was fourteen and seven-eighths inches, whereas on the sound side it was thirteen inches; shortening of the left limb, five-eighths of an inch; pulsation in the posterior tibial and dorsalis pedis arteries was unimpaired; under ether, the deformity was easily reduced by forcibly flexing the leg till the heel touched the buttock; the limb was placed on a back splint, and the patient made a perfect recovery.

CASE VIII.—*Separation, with Inflammation of Knee-joint and Excision of the Joint.*—CANTON.¹ W. J., aged fifteen, was playing with another boy, and, with a view of eluding him, was about to run under the body of a horse which stood close by. The animal, however, seeing him approach, rose on his fore-feet, knocked him down and kicked him violently above the left knee with one of his hind hoofs. On examination the affected limb was shortened, foot everted, leg slightly flexed, much swelling round the knee, and with such distortion of the parts as to give the impression of the tibia being displaced backward and outward; the inner femoral condyle appeared to project unduly, and the skin covering it was tense and abraded; crepitus was elicited; on the outer side and above the patella a forward elevation of bone could be felt. On account of the restlessness of the boy inflammation of the knee-joint set in with suppuration, so excision was performed. On examining the parts removed, the lower epiphysis was separated for about three-fourths of its circumference, while the remaining fourth was still firmly fixed in its normal position. An oblique fracture also extended through the substance of the shaft upward and outward from the line of separation. The patient *is said*² to have made a perfect recovery.

CASE IX.—*Compound Separation of Lower Epiphysis; Amputa-*

¹ Trans. Path. Soc., Vol. XI, p. 195.

² Italics are mine.

tion ; Death.—HOLMES.¹ (Specimen is in the Museum of St. George's Hospital.) Boy, aged eighteen, was leaping from a pier on to a steamboat when his leg caught, and became entangled in a rope. There was a compound fracture of his thigh at the lower third, an extensive laceration of the skin in the groin, besides the injuries to the bone shown in the preparation. He died after operation from pyæmia. The lower epiphysis of the femur and tibia, and both of the fibulæ, were found separated.

CASE X.—CALLENDER.² F. W. P., aged eleven, sustained a severe lacerated wound on the inner side of the knee, together with separation of the epiphysis. This was caused by getting the leg entangled in the wheel of a cart while he was hanging on behind. There was firm union in six weeks without shortening of the limb. The boy was seen sixteen months later, and the growth of the femur had not been interfered with.

CASE XI.—M. COURAL.³ A boy, eleven years old, fell forward while his leg was buried in a hole up to his knee, separating the lower epiphysis from the shaft, at the same time driving the shaft behind the condyles into the popliteal space. The epiphysis became tilted in such a manner that its lower extremity was directed forward. The limb was amputated.

CASE XII.—*Separation of the Lower Epiphysis of Femur and Upper Epiphysis of Tibia in a Child at Time of Birth.*—MALGAIGNE.⁴ Madame La Chapelle mentions a case in which traction on the foot of a child in the act of birth caused a separation of the above-mentioned epiphysis. The child was born dead.

CASE XIII.—*Compound Separation of Lower Epiphysis of Femur, Secondary Hæmorrhage and Amputation.*—LITTLE.⁵ A boy, aged eleven, while hanging on the back of a wagon had his right leg caught between the spokes of a wheel. Shortly after the accident Little found the upper fragment of the femur projecting through an opening on the upper and outer part of the popliteal space. The wound did not appear to communicate with the knee-joint. The fragments were reduced under an anæsthetic, the reduction occasioning a dull cartilaginous crepitus. There was at the time no pulsation

¹ Trans. Path. Soc., Vol. XIII, p. 187.

² St. Bart. Hosp. Rep., Vol. IX, p. 34.

³ Hamilton, Fractures and Dislocations, p. 460.

⁴ Quoted by Hamilton, op. cit., p. 460.

⁵ New York Med. Journ., Nov., 1865, op. cit., pp. 460, 461.

in the posterior tibial artery. The limb was laid over a double inclined plane. Next day displacement was found to have occurred again, and the fragments could only be kept in place by extreme flexion of the leg. This position was therefore adopted and maintained.

Considerable traumatic fever followed, and secondary hæmorrhage on the thirteenth day. This arose from the anterior tibial artery near its origin; and it became necessary to amputate. The boy made a good recovery. The specimen showed that the line of separation had not followed the cartilage throughout, but had at one point traversed the bony structure.

CASE XIV.—Dr. VOSS, at the same meeting of the New York Medical Society at which Dr. Little presented his case, remarked that he had met with the same accident. There was no protrusion of bone, but an abscess formed; and it became necessary to amputate.

CASE XV.—Dr. BUCK also had seen a case which occurred in the practice of Dr. Hugh Walsh, of Fordham. The subject was a boy, aged fourteen years, and it occurred in the same way as in Dr. Little's patient.

CASE XVI.—HOLMES.¹ A boy, aged sixteen, fell from a height of eighty feet. The lower epiphysis of the femur was completely separated from the shaft and twisted upon itself. There was also a wound of the knee-joint. The thigh was amputated.

CASE XVII.—*Compound Separation of Lower Epiphysis of the Femur.*—ALCOCK.² A child, aged six years, got his leg entangled in the wheel of a carriage behind which he was riding. A large lacerated wound across the ham ensued, from which the shaft of the femur separated from the epiphysis and, denuded of periosteum, protruded. The patella was uninjured; reduction was then impossible; part of the protruding shaft was sawn off, and the remainder reduced; the limb was put up in the semi-flexed position; the limb was disturbed in the night, however, and the position altered. Finally, after a hard struggle for life, the wound healed with the leg at an angle of seventy-five degrees with the thigh, and the patient walked about with crutches. Alcock believed amputation would have been preferable, as he thought a lower limb much bent to be a greater evil than its total loss.

CASE XVIII.—PUZEY.³ A. L., aged sixteen, was playing leap-

¹ Trans. Path. Soc., Vol. XIII, p. 187.

² Med. Chir. Trans., 1840, p. 311.

³ Brit. Med. Journ., 1882, Vol. II, p. 788.

frog, and in alighting with his legs rather farther apart than usual, fell ; on attempting to rise, he found his knee out of joint ; on examination he looked as if he were the subject of a well-marked genu-valgum of the right knee ; the leg was lying flat on the bed, but fixed at an angle of about 130° with the thigh ; much fulness about the joint, and any attempt at movement caused great pain ; under ether, the ordinary movements of the knee-joint were found to be free ; and the inner and outer condyles bore their normal relations to the tuberosities of the tibia ; but the leg remained fixed in its extraordinary position. On steadying the lower part of the thigh, and by gently pushing the leg towards the middle line, the deformity was reduced with soft crepitus.

Treatment.—The limb was put up on a Macintyre's splint, and an ice bag applied. The splint was kept on for seven weeks ; and then the boy was allowed to move the knee. Result : Six months later he was found to have a good, straight limb, with perfect movement of the knee-joint.

CASE XIX.—SHEPPARD.¹ A boy, aged fifteen, was riding on the back rail of a cab, when his left leg became entangled in the hind wheel ; he was thrown violently from his position into the road, and being unable to stand was taken to the hospital. On admission the left leg lay slightly flexed, and there was considerable displacement of the knee inward ; on the front and inner side of the knee there was a rounded prominence, smooth to the touch, evidently the lower end of the shaft of the femur ; the lower epiphysis of the femur was apparently projecting into the popliteal space, but it could not be felt there ; the whole knee-joint, including the epiphysis of the femur, was displaced outward and backward ; the upper fragment, or the shaft, was displaced forward and inward ; some indistinct crepitus was felt on manipulation.

Treatment.—Reduction was effected by means of traction with the limb in the flexed position, and a hand behind the head of the tibia, combined with gentle manipulation of the projecting end of the shaft ; the limb was placed upon a splint in a slightly flexed position. Result : Two months afterwards the movements were nearly perfect.

CASE XX.—*Compound Separation ; Occlusion of Popliteal Artery and Vein ; Stretching of Internal Popliteal Nerve ; Anterior Dis-*

¹ St. Thomas's Hosp. Rep., 1878, p. 433.

placement of Epiphysis; Amputation; Recovery.—MAYO ROBSON.¹ A. B., aged fifteen years, had his leg crushed in a colliery accident. The circulation in the injured limb was impeded from the first, and on the forty-third day amputation of the thigh was performed for gangrene. The specimen is now preserved in the Leeds School of Medicine Museum, and shows the lower end of the diaphysis projecting into the popliteal space, and tightly stretching the large vessels and internal popliteal nerve; while the detached epiphysis is seen lying with its fractured surface on the front of the femur, its articular surface being directed forward; its anterior margin upward, and its posterior downward; the gastrocnemius is attached to the diaphysis.

CASE XXI.—*Compound Separation.*—MAYO ROBSON.² F. C., aged six years, was brought to the infirmary; the lower end of the diaphysis projected through a wound in the popliteal space; while the epiphysis was displaced downward and forward; amputation of the thigh was performed with good result.

CASE XXII.—MAYO ROBSON.³ C. T., aged fifteen, while adjusting a belt, was caught up and whirled round a shaft several times; he was not brought to the infirmary till the next day, when the swelling was so extreme that no diagnosis could then be made.

As soon as the swelling had subsided there was found to be a fracture of the head of the left tibia; whilst on the right side the leg was thought to be dislocated forward; reduction was attempted under ether, but could not be effected; it was found later there was one and a half inches shortening of the thigh, with projection of the shaft into the popliteal space, and displacement of the epiphysis anteriorly on to the front of the shaft of the femur; ten weeks afterwards, with full antiseptic precautions, Mr. Atkinson made the usual incision for excision of the knee, and by means of a chisel and mallet detached the condyles from the front of the femur, where they had become firmly fixed, and sawed off the rounded end of the diaphysis and articular end of the tibia.

Museum Specimens.—Hunterian Museum,⁴ No. 1041. "The bones of a knee-joint. The epiphysis of the femur was separated by

¹ Liverpool Med. Chir. Journ., Vol. 111, p. 262. Under the care of Mr. Wheelhouse.

² Loc. sup. cit. Under the care of Mr. Hey.

³ Loc. sup. cit. Under the care of Mr. Atkinson.

⁴ Museum Catalogue.

violence from the shaft three years before amputation ; the shaft was forced downward and backward. In this position a firm, smooth reunion has taken place with very little deformity or shortening. From a girl, aged eleven, whose leg was caught in a wheel ; after the accident the knee was painful and swollen, and she halted in walking, but nothing particular ensued until three years after her apparent recovery from the accident, when a large abscess formed in the ham, and communicated with the knee-joint. For this the limb was amputated and the patient recovered.

“No. 1041 A. The lower end of the femur and knee-joint showing a separation of the lower epiphysis of the femur. The separation has not taken place cleanly, but a portion of bone has been broken off from the diaphysis. From a boy, aged twelve, who was severely injured a week before death, by his leg being caught in some machinery. The periosteum covering the lower third of the femur was separated by a collection of blood and pus from the bone.

“No. 1041 B. The lower end of a femur showing separation of the lower epiphysis with splintering of the shaft. From a boy who had sustained a severe injury by the wheel of a tram-car passing over his leg.

“In St. Bartholomew's Hospital Museum is one specimen.

“In Guy's Hospital Museum are three specimens, from boys, aged seventeen and fourteen, and one whose age is not stated. In the first two, the injury was caused by machinery accidents, and in the second case four inches of the shaft protruded through the skin. There was also fracture of the skull, and death ensued in two hours.

“In St. Thomas's Hospital Museum, there is one specimen from Sir William MacCormack, but no history is recorded. There is also a vertical fracture into the joint ; at the outer part of the separated epiphysis is a large sequestrum.

“In the London Hospital Museum is one specimen taken from a patient who was run over.

“In St. George's Hospital Museum is a specimen of partial separation of the lower end of the femur with oblique fracture. The inner part of the epiphyseal line is separated, and running upward and outward is an oblique fracture through the diaphysis, separating off a small portion of the lower end of the femur. The specimen was taken from a baker's boy, aged fifteen, who caught his leg in a machine used in the process of bread-making. Amputation was performed immediately on admission. He died four days afterwards.

"Two other specimens are taken from cases described above. See Cases IX and XVI.

"In Charing Cross Hospital Museum is the specimen from which Case VIII is taken."

Remarks.—In considering these cases it will be well to note the anatomy of the parts. The epiphyseal line is directed slightly downward and backward, so that in the event of separation the lower fragment will often slip to the front of the shaft, which is displaced in the opposite direction. Assisting the displacement are the actions of the gastrocnemius and plantaris, which are attached to the shaft just above the epiphyseal line, and pull on it with considerable force. The epiphyseal line is just above the limit of the knee-joint behind, so that there is but little, if any, check to the displacement.

The ossific nucleus of this epiphysis appears at the ninth month of foetal life, and is united to the shaft soon after the twentieth year. It is of great importance to remember that the proliferation of cartilage of this epiphyseal line is largely responsible for the growth in length of the limb.

Of twenty-seven instances, in which the sex is recorded, it occurred once only in a girl. The average age of the cases was thirteen and a half, the highest being twenty and the lowest one and a half years. Packard¹ says: "As far as I know, in all recorded instances the patients have been males and the ages under sixteen." He also states "the cause of this injury has been in almost every case, I believe, indirect violence." Let us examine the causes. In thirteen out of twenty-six instances, to which I have had access, the injury was due to the limb being entangled in a wheel, either by a patient riding behind a cart and getting his foot caught between the spokes, or else due to entanglement of the limb in machinery. On one occasion very severe injuries to a boy occurred by his jumping from a steam-boat and getting the leg entangled in a rope. In this case at least four epiphyses were separated. Twice the injury was occasioned by slipping of the foot, the boys coming to the ground

¹ Loc. sup. cit., p. 216.

with their legs bent under them ; once a push on the outer side of the right leg was sufficient to cause it when both legs were extended and nearly fully abducted. In one instance the patient was run over, but the exact position where the wheel passed over the limb is not stated ; hence it is not possible to say whether the violence was direct or indirect. As instances of direct violence, the injury was caused in Case VII, by the blow of a heavy iron plate on the part, and in Case VIII, by a kick from a horse.

But, I think, the fact that in no less than thirteen out of twenty-six instances the history being so uniform and, indeed, identical—viz., a wheel accident, either of a cart or machinery—should lead us to suspect the nature of the injury, when occurring in boys at the age of twelve to sixteen. The giving way of the epiphyseal line under the influence of a twisting force shows that it is a weaker spot in the limb when placed in comparison with the ligaments of the knee-joint. Dislocation is infrequent in adults and very rare in children.

Symptoms.—(1) Pain may or may not be a striking feature of the case. Sometimes it is noticed to have been extremely acute, due, no doubt, to the sudden stretching of and pressure on the internal popliteal nerve.

(2) Crepitus,—although noted in some cases as soft and readily elicited, yet in most cases it was not obtainable, due, probably, to the fact that at the separated surfaces the line of solution is tolerably plain, and the fragments rub lightly over one another. Sometimes the separation was so great that the surfaces were not in contact.

(3) Deformity.—Once it was noticed that the limb had the position of a genu-valgum, and when the patient flexed the thigh, the knee-joint appeared higher up than usual. Generally, the knee was semi-flexed and the foot everted ; the patella also being turned outward. Unfortunately, the total amount of shortening is not noted.

With reference to the position of the lower fragment, this is frequently displaced forward, and sometimes rotated outward or inward, while the lower end of the shaft projects backward in the popliteal space and forms a hard mass, somewhat rounded at its

extremity. But the smoothness of the lower end of the shaft will depend upon the exact site of separation. As a rule, this does not pass entirely through the growing line, but some fragments of the shaft come away with the epiphysis.

This frequent displacement forward of the epiphysis is a very striking feature of the injury, and is doubtless due to the position of the epiphyseal line below the attachments of the gastrocnemius, and its direction downward and backward.

(4) At the level of the upper border of the epiphysis there is a transverse depression on the front of the thigh.

(5) In some instances the patients, when lying down, were able to flex the thigh slightly.

(6) Age under twenty.

Diagnosis.—(1) From dislocation of the knee forward. Here the tibia presents a distinct projection in front of the joint, and above this there is a marked depression in which the patella is felt. The lower end of the femur forms another projection in the popliteal space, behind the head of the tibia, pressing upon the popliteal vessels and nerves so that severe pain is felt in the leg, and in many instances the circulation through the tibial arteries is found entirely arrested. The anterior and posterior projections, the pain and arrest of circulation simulate displacement of the epiphysis, but in dislocation the knee is extended not flexed, and on reduction the deformity finally disappears. In separation the relations of condyles, patella, and tuberosities are not altered, and great difficulty is experienced in maintaining the reduction. In addition, dislocation is a rare accident under twenty, as has been stated.

(2) From supra-condyloid fracture of the femur. In some respects the symptoms are alike. But in fracture, the lower fragment is drawn backward into the popliteal space by the action of the gastrocnemius, while the upper projects forward, whereas the reverse frequently obtains in separation. Another point is the character of the crepitus in fracture.

Effects and Results.—On integuments.—Of twenty-nine cases, no fewer than twelve, or nearly 41.4 per cent., were compound. In all cases, where protrusion of bone occurred, it was

the shaft, and that generally at the inner and posterior part of the popliteal space, and, less frequently, at the outer and posterior part.

On the joint.—In one instance it is mentioned that the joint was opened. As we might expect, the injury gives rise to great swelling of the knee, due to rapid effusion into the synovial membrane. This is noted as having occurred chiefly in cases due to indirect violence.

On the vessels.—In one instance these are described as being torn; in another, a great deal of hæmorrhage ensued, perhaps from a partial rupture of the popliteal vein or artery, and necessitated amputation. But the opportunity of thus verifying the cause of hæmorrhage was not taken. On another occasion it was found impossible to reduce the displacement, and, as the vessels were placed continuously on the stretch by the abnormal position of the shaft in the popliteal space, gangrene set in. As instancing the condition of the artery and vein, I might allude to a case of this nature in which the limb was amputated on account of the generally severe injuries. When it was dissected it was found that the popliteal artery at the upper end of the space, and corresponding with the level of the lower end of the shaft of the femur, was completely occluded. There was no rupture of the external coat, nor was there blood in its sheath. On slitting the vessel up, the interior was found full of clot, and the inner and middle coats were lacerated; the intima was rolled up and partly reflected, forming a little pouch. McGill observed, however, in Case VII, that, although the popliteal vessels were so much displaced, and could be felt beating just beneath the skin, the pulsation in the anterior and posterior tibial arteries was good. This points to the possibility of saving the limb even when the displacement is severe, if reduction be effected early.

On the nerves.—As the internal popliteal nerve is in so intimate a relation with the vessels, when the latter are stretched the former also suffers. This accounts for the severe pain felt in simple cases. In compound cases the shaft glides past the nerve, and so the pain is by no means so severe.

Other results are: Gangrene, which has already been alluded

to, diffuse suppuration and pyæmia. Amputation has frequently followed.

The union is generally good; but in one case it is noted that the position of the limb was very bad, the leg being bent at an angle of 75° with the thigh.

Generally the movement in the knee-joint afterwards is good, and shortening is very slight, not exceeding one-fourth of an inch some months later.

Treatment.—In simple separations the first thing to do is to effect reduction, and this is in all cases best effected by placing the patient under an anæsthetic. Considerable difficulty, however, was experienced by Mr. Poland, who acted for Mr. Hilton in Case III, and reduction was only successfully accomplished the next day, by forcibly extending the leg for a long time and then pushing the shaft of the femur forward. McGill succeeded by flexing the leg until the heel touched the buttock.

In Puzey's case, where the epiphysis was displaced outward, reduction was effected by gently pushing the leg towards the median line. Sheppard found that a combination of movements was most successful, and so employed traction with the limb in the flexed position, and the hand behind the head of the tibia combined with gentle manipulation of the projecting end of the shaft. When replacement is secured it is by no means easy to maintain.

As to splints.—Liston's or Desault's back and two side splints, or Bryant's splints have all been used, but I should be inclined to recommend Bryant's splint for the first four weeks and then put on Croft's plaster-of-Paris splint until the union is firmly consolidated. In compound cases every effort should be made to reduce the deformity, even to the extent of sawing off a small portion of the diaphysis, since the cartilage usually goes with the epiphysis, and the wound should be rendered antiseptic. Bryant's double splint will be found very useful until the wound has healed.

The indications for amputation are: Other severe injuries in the same limb, from which it would seem impossible for the patient to recover; when the popliteal vessels are so injured at the time of accident that the circulation is completely arrested, and when gangrene is impending or has already set in.

SEPARATION OF THE UPPER EPIPHYSIS OF THE TIBIA.

The literature of this injury is very scanty, and I am able from general sources to present only seven instances; but many cases of this and allied injuries await publication from the case-books of large hospitals.

CASE I.—MANLY.¹ A young man, aged twenty, when riding a bicycle, collided with a hansom cab and was thrown off. He struck the inner side of the left knee. On examination there was a good deal of effusion into the joint, and below the knee on the inner side a distinct edge could be felt, apparently the upper edge of the diaphysis of the tibia; by manipulation this projection could be obliterated and distinct movement obtained between the epiphysis and shaft of the tibia, accompanied by a slight cartilaginous crepitus; the limb was put up in plaster of Paris and did very well.

CASE II.—HEUSTON.² A boy, aged eight years, was caught by the leg between two desks. In attempting to wrench the limb free the accident occurred. At the time there was but little pain and he was able to walk home. A large amount of swelling occurred. On examination I found all the local evidences of acute synovitis of the knee, while free movement could be obtained between the upper epiphysis of the tibia and the shaft; there was, however, no crepitus.

CASE III.—*Separation of Upper Epiphysis of the Tibia by Extension (?)*—J. JONES.³ A boy, aged fifteen, with hip-joint disease, was treated by extension. Two months afterwards a grating could be felt and deformity appeared just below the knee-joint, which was found to be due to separation of the upper epiphysis of the tibia. "I ascribe the lesion to the pull of a seven-pound weight." On removal of the weight good union occurred with the aid of rest and a back splint. Result:⁴ The patient at the present time is in excellent health but pallid; the total lameness of the limb is two inches, of which three-fourths of an inch occurs below the knee and due to the separation, a striking example of the arrest of growth of the bone on being separated from its epiphysis.

CASE IV.—STIMSON.⁵ A child, eighteen months old, was run

¹ Brit. Med. Journ., September 22, 1888.

² Brit. Med. Journ., July 21, 1888.

³ Lancet, Vol. 1, 1881, p. 282.

⁴ Lancet, Vol. 1, 1883, p. 403.

⁵ Med. Rec., July 15, 1882.

over by a "horse-car," and the upper epiphysis of the tibia was completely separated from the shaft; the upper end of the shaft was denuded of its periosteum, which was adherent to the epiphysis.

CASE V.—See Case XII, of *Separation of Lower Epiphysis of the Femur*, in which the two injuries co-existed.¹

Museum Specimens.—One in the Museum of the Episcopal Hospital, Philadelphia. A specimen from a boy whose leg was so crushed that it was necessary to perform amputation, figured by Ashhurst.²

Specimen in the Hunterian Museum, contributed by the author. Unfortunately no history was obtainable in this case, as it was found among a number of discarded specimens given to me from a private collection.

Remarks.—From the above and following notes it will be seen that there are seven cases—some of which are doubtful—recorded, and two specimens at least are in museums. The injury has been verified by dissection in Madame La Chapelle's case, in Ashhurst's case and in Klein's case. The injury is due in some cases to direct, and in others to indirect, violence.

Symptoms.—In addition to the cardinal signs of broken bone, the chief points are the age, under twenty, the backward displacement of the upper epiphysis, and the recurrence of the deformity after reduction; the movements of the knee-joint, too, are normal and free under the administration of anæsthetic.

Diagnosis.—Difficulties can only arise when there is much swelling about the parts, so as to obscure the outline of the bones. The displacement cannot be very severe because in the first place of the tongue-like shape of the lower and anterior margin of the epiphysis and the splint-like action of the upper part of the fibula, the head of which articulates with a facet which is part of the epiphysis of the upper end of the tibia. What displacement there is will exist mainly, therefore, on the inner side. The complications are effusion into the knee-joint, shortening, about three-fourths of an inch some time afterwards in Case III, and in two instances only was it necessary to amputate.

¹ See also *Separation of Lower Epiphysis of Tibia*, Case II, and *Separation of Lower Epiphysis of Tibia with Fracture of Lower End of Fibula*, Case I.

² *Prin. and Prac. of Surg.*, 3d Ed., Figs. 132 and 133.

Treatment consists in the use of back and side splints, or Croft's splint kept on for six weeks.

SEPARATION OF LOWER EPIPHYSIS OF THE TIBIA.

This is a rarer injury than separation of the lower epiphysis of both tibia and fibula, or separation of the tibia with fracture of the fibula. These combinations will be spoken of in a later part of the article.

CASE I.—R. QUAIN.¹ On October 22, 1851, a boy of seventeen was admitted into University College Hospital. He stated that, while dragging a piece of iron about twelve feet long, he slipped and fell, the left foot being doubled under him. On examination the lower end of the shaft of the tibia projected forward. This projection was found to be one and a half inches higher than the lower margin of the fibula and three-quarters of an inch above the tip of the internal malleolus; the space between the prominent edge and the end of the great toe on the injured side measured three-quarters of an inch less than on the sound side; the ankle-joint was uninjured, the edge of the displaced bone was rounded and smooth; there was but little swelling; the replacement of the bone and the treatment by means of "starch apparatus" presented no difficulty, and no circumstances requiring notice.

CASE II.—*Compound Separation followed by Necrosis of Part of the Epiphysis; Recovery.*—Voss.² Dr. Voss remarked that he had seen a case of separation in this position in a boy of fourteen years old, who, in falling, had caught his foot between two blocks of wood. The upper fragment protruded through the skin; reduction was effected, but subsequently a portion of the epiphysis became necrosed and was removed; he finally recovered with a useful joint.

CASE III.—R. W. SMITH.³ A similar accident to the preceding occurred in a boy sixteen years of age. It was seen by Smith six months afterwards, and found to be unreduced; the lower end of the shaft was displaced forward.

CASE IV.—*Compound Separation; Good Union; Good Movement in Ankle-joint.*⁴—J. W., aged thirteen, was admitted with what

¹ Brit. Med. Journ., August 31, 1867.

² N. Y. Med. Journ., November, 1865, p. 133.

³ Brit. Med. Journ., August 31, 1867.

⁴ Glasgow Med. and Surg. Journ., November, 1886.

appeared to be a compound dislocation of the left ankle. On examination it was found that the joint was not implicated and that the lesion was a compound diastasis at the lower end of the tibia. The shaft had been forced through the skin, making a wound on the inner side of the leg above the ankle about two inches in length by one and a half inches in width. The periosteum was stripped off the shaft for about one inch, and was so lacerated that it was impossible to get it to cover the bone; where uncovered, the bone was pale, but marked by bright, red spots at the openings of the vascular channels; the fibula was not in any way injured.

The wound was dressed antiseptically and side-splints applied.

Five weeks afterwards the patient was dismissed with an excellent limb, the movements of the ankle-joint were perfect, and there was no measurable shortening. On careful inquiry, the following was found to be the cause of injury: He was standing on the tramway in a mine, when a "hutch" came unexpectedly up and struck him on the outside of the left leg, about the middle; the foot was resting on the sleeper, and was supporting the weight of the body, so that the force caused the lower end of the diaphysis to be driven through the skin.

CASE V.—MR. HOLMES, *vide* Case IX, of *Lower Epiphysis of Femur; Compound*.

Museum Specimens.—Hunterian Museum, No. 1103. "Part of a tibia. The lowest portion appears to be the lower end of the shaft; it was separated from its epiphysis and protruded; it was sawn off; the other portions of the specimens were afterwards exfoliated. Specimen contributed by Sir Astley Cooper."

Middlesex Hospital Museum. A separation of the lower epiphysis of the tibia in a child.

Remarks.—The cause was generally indirect violence and the injury occurred in boys. The symptoms are graphically described in the case recorded by Quain.

Diagnosis.—From partial dislocation of the ankle outward, as in Pott's fracture. If there be but little swelling at the time the symptoms of the latter injury are sufficiently obvious, the fracture of the fibula, the prominently projecting internal malleolus, if unbroken, or, if broken, the separated fragment and the crepitus of a true bony nature are sufficient distinctions.

From Dupuytren's fracture of the fibula, the diagnosis is rather obscure; as in addition to the fractured fibula, a slip of the tibia may be torn off with the strong inferior tibio-fibular ligaments, and the tibia is sometimes forced through the skin on the inner side, rendering the injury compound. But here, as in Pott's fracture, if the swelling is not great, the fact there is a co-existent fracture of the fibula is sufficient for diagnostic purposes in the case of separation *alone* of the lower tibial epiphysis. In compound cases, either of dislocation of the ankle itself, Pott's fracture, or a separation of the epiphysis, exposing to the eye the bone, all chance of error in diagnosis is removed. But in Quain's case it is especially noted that there was a remarkable absence of all swelling about the ankle-joint.

Complications and Results.—The ankle-joint escapes injury. In two instances the lesion was compound, but in one of these, Clark's, although the periosteum was stripped off the shaft for one inch, it is especially noted that there was no shortening, and perfect movement of the ankle-joint was obtained in six weeks. Case III is an instance of deformity arising from non-reduction. In no instance does the posterior tibial artery or nerve appear to have suffered. Mr. Holmes's case of multiple separation of the epiphysis succumbed from pyæmia after amputation.

Treatment.—In the first place reduce the deformity by extension and counter-extension; then place the limb in a Croft's splint. In compound cases, I think that fuller details of Case IV than are quoted above, but which appear in original article, present ideal treatment. "The wound was well washed out with solution of corrosive sublimate and dressed with carbolic gauze and a good wood-wool pad applied and back and side splints fitted. When dressed six days after admission, the dressings were simply stained with blood. From this time the dressing was unchanged for twenty-four days, when it was removed during the visit of the local branch of the British Medical Association."

SEPARATION OF THE UPPER EPIPHYSIS OF THE FIBULA.

Hamilton¹ was unable to find any record, but Stimson has contributed the following notes of a case:

¹ N. Y. Med. Rec., 1882, Vol. xxii, p. 77.

A child, eighteen months old, was run over by a "horse-car," and received injuries which caused its death some hours afterwards. The right leg was badly lacerated, and the knee-joint was opened from the outside; the upper epiphysis of the fibula was completely separated from the shaft; the specimen was interesting with reference to two points. Firstly: The upper end of the shaft of the fibula was entirely denuded of periosteum. He had seen that fact recorded in other cases, and perhaps it had something to do with the not infrequent occurrence of suppuration after such an injury. Secondly: The separation was clean and without fracture of the bone proper.

SEPARATION OF THE LOWER EPIPHYSIS OF THE FIBULA.

Again I have been able to come across but one example of this injury existing by itself, and not associated with the separation of the lower tibial epiphysis.¹

A boy, aged eight, was caught by the leg in some machinery, and the soft parts sustained a very extensive laceration. "After amputation there was found a disjunction taking place at, and coinciding exactly with, the width of the epiphyseal line, leaving the shaft of the fibula intact." Hamilton says: "I have not been able to meet with a single case."

SIMULTANEOUS SEPARATION OF THE LOWER EPIPHYSIS OF THE TIBIA AND FIBULA.

CASE I.—ADAMS.² A boy, aged fourteen, in jumping off a bar of iron caught his toes, and fell forward with much violence, so that the lower epiphysis of tibia and fibula on the left side were detached, and then dragged backward with the foot of the patient. The strength of the lateral ligaments of the joint will account for the occurrence of this lesion rather than dislocation. Had the patient been an adult, dislocation would probably have ensued, in the place of diastasis. The symptoms were well marked, especially the projection forward of the lower end of the tibial shaft. Both Adams and Ward concurred in the diagnosis. Reduction was effected with considerable difficulty, and splints were applied.

CASE II.—FISCHER; HIRSCHFELD.³ Specimen taken from a

¹ Path. Soc. Trans., Vol. xxxv, p. 272, and is recorded by Mr. Bland Sutton.

² Med. Times and Gaz., February 12, 1859.

³ Berliner klin. Wochen., 1865, p. 63.

youth, seventeen years of age, in whom the lower epiphyses of the tibia and fibula were found to be torn away near the epiphysal line, and there was also separation of the upper epiphysis of the tibia.

CASE III.—ANGER.¹ A youth, fifteen years of age, got his leg entangled in machinery; the lower epiphyses of the tibia and fibula were separated; the shaft of the tibia was broken at the outer side.

CASE IV.—CORNER.² A boy, aged fourteen and three-quarter years, was seated on the tail-board of a cart, which gave way; he alighted on his feet, the injured foot turning inward; the symptoms were great swelling about the ankle-joint and deformity looking like dislocation of the foot backward, the os calcis being drawn backward and upward; on tracing the crest of the tibia a depression was felt from one to one and a half inches above the ankle-joint, and some motion at this part was noticed on pretty forcible manipulation, but there was no crepitus; the external malleolus pointed more posteriorly than on the opposite side; the limb was placed in Luke's swing apparatus, but the os calcis was still displaced; on the leg being flexed and placed in a splint on its outer side, displacement was reduced.

CASE V.—*Separation of Lower Epiphysis of the Tibia on Right Side, and Fracture of Fibula, with Compound Fracture of Os Calcis and Scaphoid; on Left Side Separation of Lower Epiphyses of Tibia and Fibula, and Comminution of Os Calcis.*—HUTCHINSON.³ A sailor, aged nineteen, was standing on a rope under a yard unfurling a sail as his ship was leaving the dock; his foot slipped, and he was left hanging to the yard by his hands; he held on till he was exhausted, and then fell to the deck, coming heavily on his feet; the height was about twenty or thirty feet; on admission a lacerated wound three inches long was seen on the inner side of the right foot, and through this wound a comminuted fracture of the os calcis could be felt; on both sides there was separation of the lower ends of the tibia and fibula; both feet were displaced backward, carrying with them the lower ends of the tibia and fibula; reduction was easily effected, and a good position maintained by outside splints and foot-pieces; seven days afterwards he had an attack of erysipelas, of

¹ *Traité des Malad. Chirurg.*, Paris, p. 18.

² *Med. Times and Gaz.*, March 5, 1859.

³ *Lancet*, 1875, Vol. II, p. 857.

which he died ; the nature of the lesions was verified by post-mortem examination.

Remarks.—It has been thought better to group these cases together, as they can be more readily and concisely dealt with. I have given notes of three cases and brief notices of two cases. In all instances the injury was probably due to indirect violence. The ages were fourteen, seventeen, fifteen, fourteen, nineteen.

Symptoms.—In four instances the foot was displaced backward, and there was a forward projection of the tibial shaft. Below this there was a depression from one to one and a half inches above the ankle-joint ; and the outline of the lower part of the fibula was interrupted just above the external malleolus. There was also some motion at these points. No crepitus of any kind was felt.

The carrying backward of the foot with the displaced epiphysis was due to two causes,—the direction of the violence, and the action of the gastrocnemius and soleus on the os calcis.

Diagnosis.—From backward dislocation of the ankle: In separation, on tracing the tibial crest from above downward, it will be felt to cease abruptly about one inch above the ankle, and the outline of the fibula will also be interrupted ; further, the fibula has lost its spring. On measurement from the tips of the internal and external malleoli to the bases of the first and fifth metatarsal bones on both sides, there will be no difference ; whereas, in dislocation forward there will be decrease on the injured side. Difficulties will arise if a great amount of swelling suddenly ensue ; but if, as in Case I, the patient can be seen before the swelling supervenes, the diagnosis does not present great difficulty.

Effects.—As to the subsequent position and appearance of the limb it should be further noted in Case I that Adams says, "firm union took place, and the boy left the London Hospital with a very good leg." There is no history of any implication of the ankle-joint.

Treatment.—By flexing the leg on the thigh and applying traction to the foot, reduction can be very easily effected, and an outside splint with foot-piece, or a Croft's splint, is all that is necessary.

SEPARATION OF THE LOWER EPIPHYSIS OF THE TIBIA, WITH FRACTURE OF THE FIBULA.

CASE I.—*Separation of Lower Epiphysis of Tibia, Fracture of the Fibula, Compound Separation of the Upper Epiphysis of the Tibia; Amputation; Death.*—E. KLEIN.¹ A boy, thirteen years of age, was injured by a threshing-machine; death, three-quarters of an hour afterwards, from collapse. The above lesions were found.

CASE II.—WADE² (reported by R. W. Smith). There was compound separation of the lower epiphysis of the tibia, a large wound existing at the inner side of the leg, with much bleeding. There was also fracture of the fibula. Primary amputation was performed.

CASE III.—*Compound Separation, followed by Gangrene, Pyæmia and Death.*—P. BRUNS.³ A youth, aged seventeen, fell between the spokes of a wagon-wheel; there was separation of lower epiphysis of the tibia, with splintering and diaphysis; this was compound; there was also fracture of both femora; gangrene of both legs ensued, and death took place in nine days, from pyæmia.

CASE IV.—MARTIN.⁴ A boy, eleven years of age, fell from a height. At the inner side of the leg the diaphysis of the tibia protruded, the periosteum being stripped off for about one and a half inches; the fibula was also fractured, replacement was effected with much difficulty; the wound was healed in two months.

CASE V.—*Compound Separation of Lower Epiphysis of Tibia, with Fracture of Fibula.*—CLARK.⁵ A boy, aged thirteen, was admitted into the Infirmary with what was at first supposed to be a compound dislocation of the ankle. He had been struck on the inner side of the leg by a large sheet of iron. On examination there was found to be a wound about two inches in diameter, much lacerated,

¹ Inaug. Dissert., 1854.

² Dublin Quart. Jour., 1852, Vol. XIII, p. 202.

³ Langenbeck's Archiv, B. XXVII, p. 276.

⁴ Boston Med. Jour., 1877, Vol. II, p. 127.

⁵ Glasgow Med. Jour., 1886, Vol. II, p. 329.

and through which protruded the end of the shaft of the tibia; this was rounded and had no appearance of fracture; the periosteum was completely stripped off the bone for about two inches on the inner side, and somewhat less on the outer; the ankle-joint was uninjured, so also were the tibial arteries and nerves; the fibula was fractured about two inches above the tip of the external malleolus. To reduce the deformity it was found necessary to resect three-quarters of the exposed shaft; the wound was dressed antiseptically, but suppuration took place, and the wound healed by granulation. Two years afterwards the boy was seen again, and there was found to be a shortening of two centimetres, that is, nearly the amount resected in reducing the displacement immediately after the injury. It would, therefore, appear that there was but little, if any, arrest of the growth of the limb, as the lad himself had grown considerably in height during the interval. The movements of the ankle-joint were perfect, and the patient could bear all his weight upon the limb.

Remarks.—It is curious to note that all the cases were compound. The causes were wheel accidents or the fall of a large sheet of iron on the inner side of the leg. The diagnosis, in most of the cases, was easy, since the ends of the bones could be either seen or felt, although Clark's case was at first supposed to be a compound dislocation of the ankle. In a simple case there would be no little difficulty in diagnosing it from a Pott's fracture, but in the latter case the continuity of the anterior margin of the tibia is not destroyed. Then again, it will be found that in separation, the *whole* of the lower extremity of the tibia goes with the foot, whereas in Pott's fracture the internal malleolus alone is broken off, as a rule. Dupuytren's fracture of the fibula is diagnosed by the fact that, when the foot is moved outward, the internal malleolus does not go with it as in separation.

Effects and Results of the Injury.—In all the quoted cases it was compound. On the vessels and nerves; In Case V they were exposed and uninjured; in Case II there was very free hæmorrhage, but the origin of it is not stated. Judging from the fact that amputation was soon performed, it is probable that one or both the tibials were damaged. Among the other effects of the injury the stripping of the periosteum off the shaft of the tibia should be noticed. This is explained in nearly all cases by

the peculiar disposition of the periosteum at the epiphyseal line. If this membrane be traced from the shaft towards a joint it will be seen to divide at the epiphyseal line into two processes, one the stronger, which turns inward and blends with the cartilage of the growing line, and the other, which passes over the epiphyseal bone to blend with the capsule of the joint. So that the end of the shaft is surmounted by a cap of periosteum and epiphyseal cartilage. The periosteum remains more firmly attached to the epiphyseal line than to the shaft, hence the partial denudation of the latter.

Treatment.—After reducing the fragments and rendering the wound aseptic, the leg should be put up in a back and two side splints. Amputation is called for if both tibial arteries are lacerated, and if there be extensive injury in other parts of the limb.

SEPARATION OF THE EPIPHYSIS OF THE FIRST PHALANX OF THE GREAT TOE.

GASCOYEN.¹ A child, aged eight, three months previously, while at play, got the great toe fixed under a door and struggled hard to release it. On examination it was found that the head of the metatarsal bone of the great toe was unnaturally prominent, and the extensor longus pollicis tendon extremely tense, the end of the toe being raised; there was a little pain on manipulation, but no grating; the head of the metatarsal bone could be felt intact with a rounded *movable* piece adherent to it, upon which the toe appeared to play; extension completely reduced the deformity, which returned when the extension was removed. Gascoyen, accordingly, made the diagnosis of separation of the epiphysis of the first phalanx of the great toe, and divided the extensor longus pollicis tendon; after the wound was healed, the foot was put into a gutta-percha splint, which was firmly moulded to the toe. The child did well, and in three weeks was able to walk about almost naturally, whereas, at first, the position appeared to have been that of talipes equino-varus.

Remarks.—It is to be regretted that in an obscure unique injury such as this, the opportunity afforded by operation was not taken to verify the precise nature of the injury. But the case occurred in the pre-antiseptic days.

¹ Brit. Med. Journ., 1871, Vol. 1, p. 338.

PLATE I.

ILLUSTRATING SOME OF THE CHANGES OBSERVED IN ACUTE APPENDICITIS.¹

FIG. 1.—Appendix removed twenty-nine hours after commencement of attack. Gangrenous and perforated at the distal extremity. The dark body in the cavity at the tip is a fresh blood-clot resulting from the involvement of one of the branches of the appendicular artery in the gangrenous and perforating process. The appendix, in this case, was unusually free from surrounding inflammatory conditions, adhesions, etc. The perforation had taken place into the unprotected peritoneal cavity and a violent septic general peritonitis was under way. No foreign body, or even inspissated fecal matter was present.

FIG. 2.—Appendix removed twelve hours after the commencement of the attack. The appendicular artery in this case extended to the distal extremity of the organ before giving off any branches. It was then reflected in the submucosa, and gave off its branches in a direction toward the base of the organ. The vessel is seen to be occluded by a thrombostasis a short distance from its tip.

FIG. 3.—External surface of an appendix imbedded in inflammatory material and perforated about half an inch from its distal extremity.

FIG. 4.—The same appendix incised longitudinally, the line of incision crossing the point of perforation. The wall of the appendix is shown, thickened at its upper or proximal extremity and about five-eighths of an inch from the latter. A stenosis exists, the cavity beyond which had undergone some dilatation. The mucous membrane is seen to be gangrenous (green) and necrotic (yellowish-white) in spots. The larger perforation is shown in the broken line of the edge of the incised mucous membrane. Another and smaller perforation is present upon the opposite side and nearer the tip. This was a chronic relapsing case, operated upon in an acute relapse.

¹ These colored sketches were made by the artist from the fresh specimens immediately after removal.

Plate I.



Fig. I.



Fig. II.



Fig. III.



Fig. IV.

Fraxinus, hyperborea